Soils and Landforms of Northern and South Eastern Finland (Sols et paysages dans le Nord et le Sud-Est de la Finlande)

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Introduction

Fifteen soil pedons in Finland were described by scientists from the Natural Resources Conservation Service (NRCS) in the United States, geologists from the Geological Survey of Finland (GSF) at Kuopio, and scientists from the University of Poitiers in France during 1994 and 1996. These projects were funded by the United States Agency for International Development and are the first joint soil investigations between the NRCS and any Nordic country.

One objective of the project was to determine if the soil morphology of the 15 podzols in Finland are sufficient to classify them into the Spodosol soil order using the Keys to Soil Taxonomy (Soil Survey Staff, 1994). Another objective was to select a method to quantify the bulk density of organic humus layers instead of collecting clod samples. In this poster presentation, the authors present photos of several of the sampling sites and processed summaries of the physical and chemical properties of the soil pedons in central and northern Finland.

Study Area

Finland lies in western Europe at a latitude of 59.5°N at Kökarsf Järden to nearly 70°N on Finlands' borders with Russia and Norway and a longitude of 20°E at Mariehamn to 31°E at Syväjärvi. Finland's total land and water area is about 337,000 km^2, approximately the size of Montana in the western United States. There are 187,888 lakes and 179,584 islands in Finland. Elevation ranges from sea level to 1,328 meters.

Ten sites are located in the south eastern part of central Finland and five sites are located in western Finnish Lapland (Figure 1). The vegetation near the sampling sites are dominantly taiga forest in central Finland (Figure 2) and Scots pine (*Pinus sylvestris*) or birch (*Betula ssp.*) in Finnish Lapland (Figures 3 and 4).

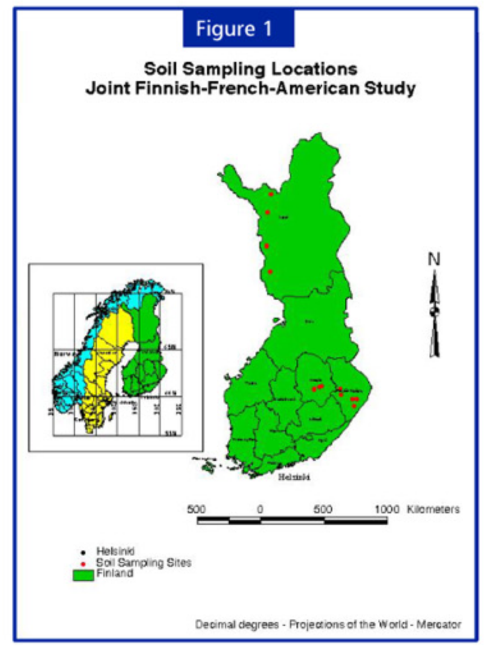

Figure 1


Figure 2


Figure 3


Figure 4

Methods and Materials

Fifteen sampling sites were selected by geologists from the GSF after consultation with scientists from the NRCS and the University of Poitiers (Figures 5 to 12). These sites represent a cross-section of landscapes, parent materials, and age in central and northern Finland (Tables 1 to 4).

A large excavator provided by the GSF was used to excavate the first six sites during 1994 (Figure 13). Hand tools were used to excavate the remainder of the sites (Figure 14). Sampling equipment was supplied by the Soil Survey Laboratory (SSL) in Lincoln, Nebraska, and all soils were described using NRCS protocols (Figures 15 and 16) (Mount et al., 1992).

No previous SSL method existed for obtaining bulk density values for thin organic horizons. Excavating clod samples of organic horizons on uplands in nearly impossible, except for well decomposed sapric material that is at least 10 cm thick. None of the sites in central or northern Finland met this criterion; therefore, a volume to weight method was designed for the study area. First, a 25- by 25-cm square of the undisturbed organic layer was cut with a knife. The square was then excavated from the top of the mineral soil (Figure 17). The depths of the individual organic horizons were first measured, then an estimation of the amount of unrubbed fiber content as well as the rubbed fiber content was documented to verify the horizon as Oi, Oe, or Oa. The organic materials were placed into 8-mil plastic sampling bags until the horizon layers were depleted. These samples were later weighed and organic carbon determined at the SSL in Lincoln, Nebraska. Weight and calculated volume of each horizon were used to approximate the bulk density.

Organic carbon values (kg m^{-2}) were calculated for the organic soil horizons using the following formula:

OC = (H * OC * Db) / 10
where:
H = horizon depth in cm
OC = organic carbon in percent (SSL method 6A1c)
Db = dry bulk density in g cm^{-3}

Total weight of organic carbon was derived by extrapolating the mean weight of the ten sites by the total area of soils formed in basal till in Finland (146,100 km^2).

Because of the low soil moisture content at several sites in south eastern Finland and all sites in Finnish Lapland, not all of the mineral soil horizons had clods extracted to measure the bulk density at the SSL in Lincoln, Nebraska. These bulk density values were approximated at the SSL using engineering analysis from the bulk samples.

One hypothesis of the project was that the 15 podzols sampled in Finland would have at least one illuvial horizon that met the definition of spodic materials as defined in the Keys to Soil Taxonomy. In addition to having an overlying albic horizon, spodic horizons must meet a set of color criteria or a set of chemical properties. A spodic horizon must be at least 2.5 cm thick. All horizons were described, with particular attention paid to those horizons that had the morphology that exhibited spodic characteristics. In addition to standard descriptive features of color, texture, moist and wet consistence, roots, pores, content of rock fragments, soil pH, and boundary, scientists documented other characteristics, including smeariness and ortstein consistence of illuvial horizons at each of the sites (Mount et al., 1996).


Figure 5


Figure 6


Figure 7

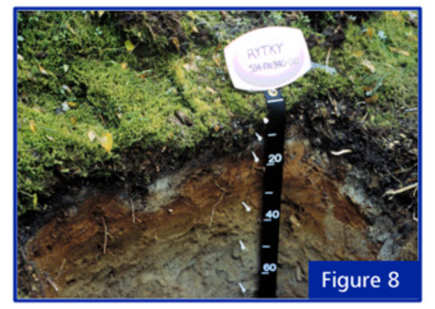
Figure 8

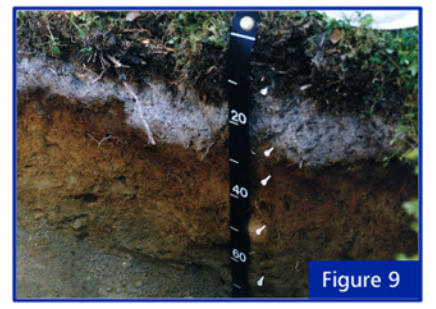
Figure 9


Figure 10


Figure 11

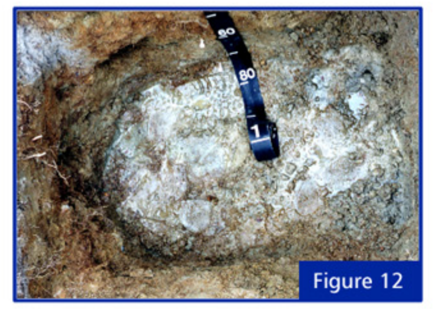
Figure 12


Figure 13


Figure 14


Figure 15


Figure 16


Figure 17

Table 1. Slope, Aspect, Physiography, Parent Material, Stone Cover, and Age of Each Pedon in South Eastern Finland.

Site No.	Soil Name	Slope (%)	Aspect (°)	Physiography	Parent Material	Stone Cover (%)	Age of Soil (Years B.P.)
1	Hopeakiva	3	215	Bedrock terrain	Lacustrine silt over till	2.0	~5000
2	Polvijarvi	7	60	Hummocky moraine	Meltout till	2.0	5000-8000
3	Suvispaa	4	0	Glaciofluvial delta	Sand and gravel	0.0	~5500
4	Suvispaa	1	300	Basal till plateau	Basal till	0.0	9500-9700
5	Kovero	21	230	Basal till veneer	Basal till	.05	9500-9700
6	Murtoi	9	260	Basal till plateau	Basal till	1.0	8000-9000
7	Ryona	5	32	Glaciofluvial ridge	Beach sand	0.0	5000-7000
8	Hirvola	9	180	Basal till plateau	Beach sand over basal till	1.0	~5000
9	Rytky	7	100	Basal till plateau	Basal till	2.0	7000-9000
10	Rytky	17	280	Basal till plateau	Basal till	2.0	~9000

Table 2. Relationship at Each Site to the Thickness of the Organic Horizon, Albic Horizon, and Spodic Horizon.

Site No.	Soil Name	Soil Taxonomy Subgroup	Organic Horizon (cm)	Albic Horizon (cm)	Spodic Horizon (cm)
1	Hopeakiva	Lithic Haplocryods	9	19	17
2	Polvijarvi	Typic Haplocryods	9	2	35
3	Suvispaa	Typic Haplocryods	4	6	48
4	Suvispaa	Typic Humicryods	12	15	106
5	Kovero	Typic Cryochrepts	6	6	36
6	Murtoi	Typic Haplocryods	8	8	27
7	Ryona	Typic Haplocryods	13	3	39
8	Hirvola	Typic Haplocryods	13	11	54
9	Rytky	Typic Haplocryods	8	17	23
10	Rytky	Typic Haplocryods	12	6	18
Mean			9.4	9.3	40.3

Table 3. Bulk Density and Carbon Summary for Sites in Central Finland (Mount et al., 1997).

Site (No)	Soil Layer	Depth (cm)	Weight (Moist <---g	Dry) --->	Total Vol. (cm^3)	Bulk Density (Moist <---g cm^{-3}	Dry) -->	Organic Carbon (%)
1	Oa	9	255	139	5,625	0.045	0.025	46.0
2	Oi	4	135	115	2,500	0.054	0.046	47.6
2	Oa	5	283	134	3,125	0.091	0.043	43.6
3	Oa	4	153	99	2,500	0.061	0.040	46.2
4	Oi	4	229	102	2,500	0.092	0.041	56.0
4	Oa	8	208	98	5,000	0.042	0.020	40.1
5	Oa	6	231	111	3,750	0.062	0.030	53.9
6	Oi	4	199	93	2,500	0.080	0.037	55.4
6	Oe	4	171	108	2,500	0.068	0.043	33.5
7	Oi	7	299	90	4,375	0.068	0.021	50.9
7	Oa	6	456	148	3,750	0.122	0.039	54.9
8	Oi	5	137	34	3,125	0.044	0.011	52.9
8	Oa	8	418	143	5,000	0.084	0.029	52.5
9	Oi	3	142	44	1,875	0.076	0.023	52.5
9	Oe	5	310	103	3,125	0.099	0.033	50.9
10	Oi	6	222	59	3,750	0.059	0.016	59.5
10	Oe	6	351	122	3,750	0.094	0.033	47.0
Mean		5.5	247	102	3,456	0.073	0.031	49.6

Table 4. Site Data for the Leppäjärvi Soil in Northern Finnish Lapland.

Site Attribute	Measured or Observed Data
Location	Finnish Lapland, 3 km east of Palojärvi Lake
Latitude	68°33'59"N
Longitude	24°23'28"E
Ecosystem	Birch tundra
Vegetation	Birch trees 4.5 to 6.0 meters tall with an understory of ericacious plants including blueberries, crowberries, and sphagnum-like mosses
Microrelief	Patterned frost hummocks in a reticulate fashion ranging from 10 to 25 cm apart, averaging about 20 cm tall
Parent Material	Basal meltout till
Slope	3 percent with a plane surface across and down, which is slightly modified by frost hummocks
Aspect	280 degrees
Altitude	360 m
Air Temperature	15°C (59°F) at 11:46 a.m. on July 8, 1996
Soil Temperature	2.8°C (37°F) at 50 cm at 12 noon on July 8, 1996
Soil Moisture	Moist in upper 85 cm and wet in the Cd horizon
Date Described	July 8, 1996

Results and Summary

South Eastern Finland

Though not required for classification purposes, the acid oxalate extraction chemistry supported the spodic morphology for 12 of 15 horizons in the ten soils of south eastern Finland. Two of the three horizons that failed chemical support were within 0.1 percent of that required by the Keys to Soil Taxonomy for acid oxalate extraction.

The method chosen to excavate the known volumes of the organic horizons, then weigh and measure their weight a the SSL in Lincoln, Nebraska in the United States, worked well. This method has provided a way of quantifying and extrapolating the total organic carbon of the organic horizons for the soils in the study area. Table 3 presents the summary of the bulk density data for the ten sites in south eastern Finland. The mean is 0.031 g cm^{-3}. There was little difference between the dry bulk density values for each stage of decomposition (Oi, Oe, and Oa horizons). Organic carbon ranged from 33.5 percent to 59.5 percent for the organic horizons and the mean for all 17 organic layers is 49.6 percent. The mean organic horizon depth for the ten sites is 9.4 cm resulting in a mean organic carbon weight of 1.24 kg m^{-2} for each site. This represents an estimated 1.8 10^8 metric tons of organic carbon on the forest floor for the soils formed in basal till in Finland. This estimate does not include urban factors such as roads, small towns, and cities. Therefore, this value needs to integrated with other kinds of resource information to affect a closer approximation.

Finnish Lapland and Northernmost Pedon

The acid oxalate extraction chemistry supported the spodic morphology for each of the five soil pedons in Finnish Lapland. The distribution of organic carbon for the Leppäjärvi soil (the northernmost soil pedon) is similar to those in south eastern Finland (Figure 18) and its weighted means for physical and chemical properties are also similar (Table 5).

When evaluating the data from the Leppäjärvi soil, it was presumed that soil processes due to successive development of plant cover started immediately after the retreat of the ice, about 9,500 years ago and 9,000 years in the Kolari-Pello area to the south. Petäjä-Ronkainen et al. (1992), have suggested that podzolization could not have started until pine spread to the area, here in western Lapland about 8,000 years ago. It can also be presumed that climate warming after the deglaciation also favored intense weathering (Hyvärinen and Alhonen, 1994). This suggestion is supported by the findings of Räisänen (1994) who substantiates the abundance of iron and aluminum precipitates in spodic horizons in northeasternmost Lapland at a latitude of about 69°40'N.

It is also presumed that cryoturbation did intensify during the past 4,000 to 3,000 years when the climate was deteriorating. According to Hyvärinen and Alhonen (1994), in that time the humidity (precipitation) increased causing the rise of groundwater level that elevated lake water levels. Van Vliet-Lanoe (1988) inferred that the increase in precipitation promotes frost heave which has caused cryoturbation features that are presently seen in podzols in northernmost Finnish Lapland (van Vliet-Lanoe et al., 1993). Northernmost podzols in Finnish Lapland are commonly characterized by bended albic and/or spodic horizons and/or a layer structure disrupted by ice wedging. In addition, hummocky microrelief characterize depressions.

A very low amount of metal-organic complexes, except in podzols rich in Mg-Fe bearing silicates, is characteristic of podzols in northernmost Finnish Lapland and at the present study site (Räisänen, 1994 and Gustafsson et al., 1995). Gustafsson suggests that the metal-organic complexes in organic horizons were formed in the warm climate period and have then slowly degraded as the climate became cooler. As a result, Fe and Al was released to the soil solution and then re-precipitated as short-range ordered minerals, which now occur abundantly in spodic horizons.

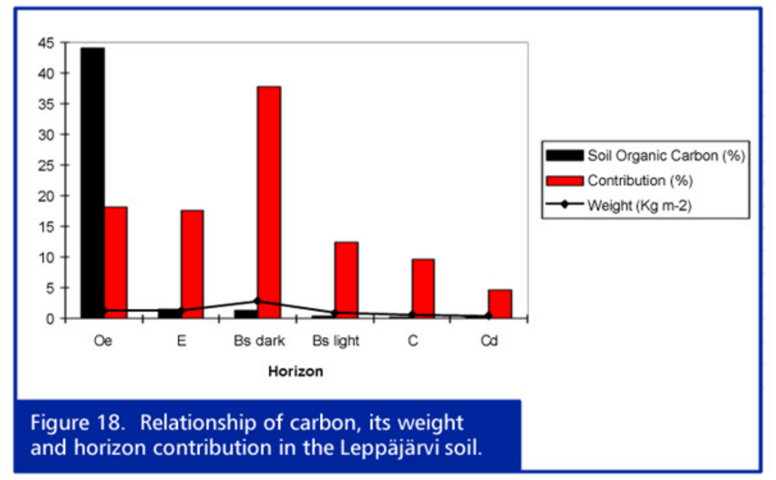

Figure 18. Relationship of carbon, its weight and horizon contribution in the Leppäjärvi soil.

Table 5. Weighted Means of Primary Characterization Data for the Leppäjärvi Soil.

Property	Mean
Total Clay	3.0% of <2 mm
Total Silt	37.3% of <2 mm
Fine Silt	18.4% of <2 mm
Coarse Silt	18.9% of <2 mm
Total Sand	62.4% of <2 mm
Very Fine Sand	11.7% of <2 mm
Fine Sand	15.9% of <2 mm
Medium Sand	16.9% of <2 mm
Coarse Sand	12.2% of <2 mm
Very Coarse Sand	5.7% of <2 mm
Rock Fragments	29.1% of whole soil
Extractable Ca	0.2 MEQ/100 g
Extractable Mg	<0.1 MEQ/100 g
Extractable Na	0.1 MEQ/100 g
Extractable K	<0.1 MEQ/100 g
CEC by Sum	8.4 MEQ/100 g
CEC by NH_4OAC	4.1 MEQ/100 g
Base Sat by Sum	4.4%
Base Sat by NH_4OAC	9.5%
pH NaF	10.6
pH 1:2 $CaCL_2$	4.8
pH 1:1 H_2O	5.8

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